Time Division Multiple Access in Clustered Wireless Networks

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ABSTRACT

Time division multiple access (TDMA) is a channel access method for shared medium networks. It allows several users to share the same frequency channel by dividing the signal into different time slots. The users transmit in rapid succession, one after the other, each using its own time slot. This allows multiple stations to share the same transmission medium (e.g. radio frequency channel) while using only a part of its channel capacity. Based on the network-wide flow distribution calculated from the optimization model and transmission power on every link, we then propose an algorithm for deriving the TDMA schedules, utilizing the slot reuse concept to achieve minimum TDMA frame length. Numerical results reveal that our proposed solution reduces the energy consumption *and delay significantly, while simultaneously satisfying a specified reliability objective.*

KEY WORDS: *Wireless Sensor Networks (WSN), TDMA*

I. INTRODUCTION

TDMA is a type of Time-division multiplexing, with the special point that instead of having one transmitter connected to one receiver, there are multiple transmitters. In the case of the uplink from a mobile phone to a base station this becomes particularly difficult because the mobile phone can move around and vary the timing advance required to make its transmission match the gap in transmission from its peers.

TDMA characteristics

- Shares single carrier frequency with multiple users
- Non-continuous transmission makes handoff simpler
- Slots can be assigned on demand in dynamic TDMA
- Less stringent power control than CDMA due to reduced intra cell interference
- Higher synchronization overhead than CDMA
- Advanced equalization may be necessary for high data rates if the channel is "frequency selective" and creates Intersymbol interference
- Cell breathing (borrowing resources from adjacent cells) is more complicated than in CDMA
- Frequency/slot allocation complexity
- Pulsating power envelope: Interference with other devices

In the seven-layer OSI model of computer networking, media access control (MAC) data communication protocol is a sublayer of the data link layer, which itself is layer 2. The MAC sublayer provides addressing and channel access control mechanisms that make it possible for several terminals or network nodes to communicate within a multiple access network that incorporates a shared medium, e.g. Ethernet. The hardware that implements the MAC is referred to as a medium access controller. The MAC sub layer acts as an interface between the logical link control (LLC) sublayer and the network's physical layer. The MAC layer emulates a full-duplex logical communication channel in a multi-point network. This channel may provide unicast, multicast or broadcast communication service.

II. RELATED WORK

The main contributions of this paper are twofold. First, we build a cross-layer nonlinear optimization model to achieve energy efficiency with specified link reliability and bandwidth constraints. Instead of solving this nonlinear optimization problem directly by heuristic algorithms, we transform the problem into two simpler subproblems at less complexity, which facilitates the application of our approach in large-size WSNs. Second, we propose a scheduling algorithm for slot assignment in clustered WSNs. This scheduling algorithm incorporates the slot reuse concept (from cellular networks) in calculating the schedules based on the optimal flows derived from the proposed optimization model. We show that the slot reuse concept significantly reduces the end-to-end latency without a penalty in the energy efficiency.

III. SENSOR NETWORK ARCHITECTURE

3.1. NETWORK ARCHITECTURE

Our assumptions for network such as, nodes are randomly distributed over an area of 400 x 500 meters with network properties. Network is static and nodes are distributed in random format, while area is divided in equal square grid format while we consider randomly one region. There exists only one base station, which is deployed at a fixed place in the random location. The energy of nodes cannot be recharged.

3.2. CLUSTERING

The nodes in the network are divided into multiple clusters, each comprising a CH and cluster members that communicate via one hop to the CH. The clustering scheme will be used to form clusters. Using the clustering scheme presented in gateways are selected to connect neighboring CHs. A gateway is a cluster member belonging to the cluster represented by one of the CHs it connects.

3.3. MINIMUM DELAY TDMA SCHEDULING

We here propose the TDMA scheduling algorithm. The scheduling includes both intercluster and intra-cluster scheduling. The tdma scheme is to assigning slots to all links, and it contains two stages. one is to assign the link slots to links between cluster members and the CH in each cluster. another one is to assign the link slots between CHs. which is called Intra-cluster slot. Intra-cluster slot assignment is usually done by the CH. For the intra-clustering schedule, First We define a frame of length M (>1) composed of M fixed length time slots. Then we decrease the slot length to reuse the slot.

To reuse the slot we will follow three criterions. Criterion 1: Node i is not the sender or receiver of a previously scheduled link using slot s, and the link of node i to be scheduled with slot s does not have the same receiver as that of previously scheduled link using slot s. Criterion 2: scheduling s as a slot used by one of node is links causes negligible interference to the receiver of a previously scheduled link also using slot s; Criterion 3: The sender of a scheduled link using slot s causes negligible interference to current receiver if using slot s on one of node i's links. For the inter-cluster scheduling, we propose a conflict free schedule among the time slots.

IV. EXISTING SYSTEM

Existing method formulate the problem via cross-layer optimization, aiming at deriving the most energy-efficient flows on every link. This implies that an optimal transmission power exists for a link to achieve power efficiency. We can say that the optimization model achieves more power efficiency in such a WSN (for example, if assuming that a backup CH near nodes exist in this scenario), since there are more choices of selecting optimal paths toward the sink even if some nodes run out of energy. CSMA especially under medium to high traffic load the main contributions of this paper are twofold. First, we build a cross-layer nonlinear optimization model to achieve energy efficiency with specified link reliability and bandwidth constraints. Instead of solving this nonlinear optimization problem directly by heuristic algorithms, we transform the problem into two simpler sub problems at less complexity, which facilitates the application of our approach in large-size WSNs. Second, we propose a scheduling algorithm for slot assignment in clustered WSNs.

V. PROPOSED SYSTEM

We propose a solution to the scheduling problem in clustered wireless sensor networks (WSNs). The objective is to provide network-wide optimized time division multiple access (TDMA) schedules that can achieve high power efficiency, zero conflict, and reduced end-to-end delay. To achieve this objective, we first build a nonlinear cross-layer optimization model involving the network, medium access control (MAC), and physical layers, which aims at reducing the overall energy consumption. We solve this problem by transforming the model into two simpler sub problems. Based on the network-wide flow distribution calculated from the optimization model and transmission power on every link, we then propose an algorithm for deriving the TDMA schedules. We aim at deriving TDMA schedules with optimized power consumption and minimum latency in clustered WSNs. Energy efficiency is a major concern in WSNs. To achieve the paper's objective, we propose a two-step approach to derive TDMA schedules supporting both high energy efficiency and minimum delay in WSNs. In the first step, we formulate the problem via cross-layer optimization, aiming at deriving the most energy-efficient flows on every link. Based on the calculated per-link flows, in the second step, we propose an algorithm to obtain a TDMA schedule with the least frame length. From the analysis presented least frame length guarantees minimum delay for the derived TDMA schedules. TDMA scheduling transmission power and retransmissions on a link determining the optimal transmission power, we build a cross-layer design-based nonlinear optimization model which aims at minimizing the network-wide energy consumption. We solve this problem by transforming it into two sub problems with less complexity.

VI. CONCLUSION

In this paper we propose a TDMA-based communication approach to be used upon the EDCA communication mechanism that is specially suited to support RT tra_c. The proposed TDMA-based approach has been assessed by simulation. The simulation scenarios consider a set of RT stations operating in the same frequency band together with a set of external STD stations. Basically, we have assessed the impact of timing unconstrained tra_c (generated by the set of STD stations) upon the behavior of the highest access category (voice). In both EDCA and TDMA models when this access category is used to transfer small sized packets in periodic intervals.

Moreover, both error-free and error-prone channels were considered. The simulation analysis shows that:
The average access delay for the TDMA mode considering both error-free and error-prone channels is kept almost constant, unlike for EDCA case. This demonstrates a desired behavior for RT applications;

Both for error-free and error-prone cases, the
TDMA functional throughput and deadline losses remains stable even with the increase of the number of RT stations, which does not occur for the EDCA case;

Both for error-free and error-prone cases, the
TDMA functional throughput is more than double when compared to the EDCA case;

Both for error-free and error-prone cases, the number of deadline losses for the TDMA case is less than half of best result for the EDCA case.

The main conclusion is that the TDMA approach keeps a stable behavior independently of the number of RT stations or the external STD load. However, the TDMA approach is able to guarantee industrial communication requirements with maximum of external
STD load of 73% in error-free channels and 47% in error-prone channels when the deadline is equal to the stream period (Di = Pi). These results significantly improve the EDCA results.

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